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Design on Synchronization Control of Dual-motor in Crane

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Abstract: In order to ensure work safety, large cranes generally use two motors together to upgrade the load, so often there is a synchronization error, control accuracy is affected. To address this issue, the paper crane hydraulic lifting system to study proposed control strategy based on fuzzy PID's. The results show that the method used to effectively reduce the synchronization error between the two motors to improve the control precision crane, a certain reference value.

Keywords Crane; Fuzzy; PID Control; Synchronization control

INTRODUCTION

Lifting system is an important part of the crane, safety, reliability is an important indicator of the performance of their work. To ensure safety, a large crane is often used to enhance the two motors with a common load, which require the same speed of the two motors or speed difference within a certain range. However, due to leakage, friction and other factors, the synchronization error often appear to make changes crane working state, prone to accidents. Therefore, this paper analyzes the dynamic characteristics of crane hoisting system, and to identify the factors affecting its synchronization accuracy; same time, the traditional PID control and fuzzy control is proposed by combining a fuzzy PID control method for crane hoisting system. The simulation and experimental results show that the control strategy used reliable and effective.

DYNAMIC ANALYSIS

Hoisting system structure

Studied in this paper crane hoisting system consists of two independent hydraulic system composition, system architecture in which a group is mainly composed of variable pump system, variable motor, solenoid valve, balance valve and other components shown in Figure 1.

Basic Model

Assume that variable displacement motor constant, according to the fluid mechanics knowledge, to realize synchronous motor speed, only need to change the displacement of variable pump. Hydraulic pump variable mechanism consists of proportional directional valve and the variable cylinder, establish its mathematical model[3][4].

1. Hydraulic cylinder flow continuity equation:

$$Q_1 - C_{tg}\,p_1 + C_{ig}\,p_2 - = \frac{dV_1}{dt} + \frac{V_1}{\beta_e}\cdot\frac{dp_1}{dt} \tag{1}$$

$$C_{ig}\,p_1 - C_{tg}\,p_2 - Q_2 = \frac{dV_2}{dt} + \frac{V_2}{\beta_e}\cdot\frac{dp_2}{dt} \tag{2}$$

Where:

V_1 -Volume of the rodless cavity; V_2 -Rod cavity volume; C_{ig} -Internal leakage coefficient;

C_{tg} -The total leakage coefficient of hydraulic cylinder; β_e—Liquid elastic modulus;

Q_1, Q_2- Hydraulic cylinder into the oil and return oil flow.

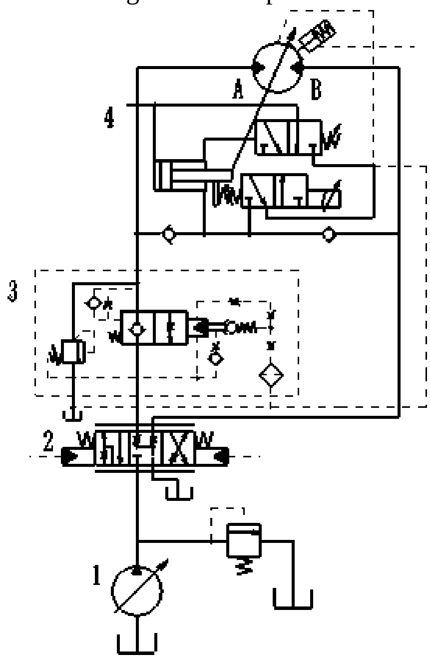
2. The hydraulic cylinder force balance equation:

$$m\frac{d^2X}{dt^2} + B\frac{dX}{dt} + KX + F_L = Ap_1 - Ap_2 \tag{3}$$

Where:

m -Mass of the piston and the load; B -Viscous damping coefficient; F_L - Load force;

X -Piston displacement; K - Spring stiffness; A - Effective working area of the piston.



1-Variable pump 2-Solenoid valve 3-Balance valve 4-Variable motor

Fig.1 Structure of the hoisting system

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3. Force equilibrium equation of spool:

$$m_v \frac{d^2Y}{dt^2} + B_v \frac{dY}{dt} + K_v Y = K_i I - K_y Y \qquad (4)$$

Where:

m_v -Quality of spool; K_i - Current gain; I - Control current; K_y - displacement gain; Y - Displacement of the spool; K_v - Spring stiffness; B_v - Damping coefficient.

RESEARCH ON CONTROL TECHNOLOGY

Fuzzy PID control

Traditional PID controller has a simple structure, the characteristics of easy to implement, but the parameters cannot be adjusted, so the application range. In order to obtain better control effect, apply the fuzzy reasoning in the setting of PID parameters, used to compensate the synchronization system due to the nonlinear and time-varying problem caused by the synchronization error, and a fuzzy PID controller structure is shown in figure 2.

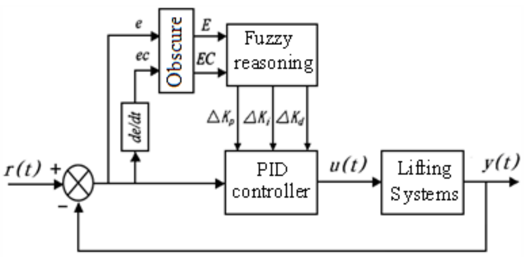

Fig.2 The structure of the fuzzy PID controller

Fuzzy control rules

Select two motor speed deviation and the deviation change rate as input variable of fuzzy controller, ΔK_p , ΔP_i , ΔP_d as output variables. On the premise of guarantee the stability of system work, give full consideration to the response speed of system and anti-jamming ability, to develop fuzzy control rules[6][7], as shown in table 1~3.

Table 1 The control rules of ΔK_p

E	EC						
	NB	NM	NS	ZO	PS	PM	PB
NB	PB	PB	PM	PM	PS	ZO	ZO
NM	PB	PB	PM	PS	PS	ZO	NS
NS	PM	PM	PM	PS	ZO	NS	NS
ZO	PM	PM	PS	ZO	NS	NM	NM
PS	PS	PS	ZO	NS	NS	NM	NM
PM	PS	ZO	NS	NM	NM	NM	NB
PB	ZO	ZO	NM	NM	NM	NB	NB

Table 2 The control rules of ΔP_i

E	EC						
	NB	NM	NS	ZO	PS	PM	PB
NB	NB	NB	NM	NM	NS	ZO	ZO
NM	NB	NB	NM	NS	NS	ZO	ZO
NS	NB	NM	NS	NS	ZO	PS	PS
ZO	NM	NM	NS	ZO	PS	PM	PM
PS	NM	NS	ZO	PS	PS	PM	PB
PM	ZO	ZO	PS	PS	PM	PB	PB
PB	ZO	ZO	PS	PM	PM	PB	PB

Table 3 The control rules of ΔP_d

E	EC						
	NB	NM	NS	ZO	PS	PM	PB
NB	PS	NM	NB	NB	NB	NM	PS
NM	PS	NM	NB	NM	NM	NS	ZO
NS	ZO	NS	NM	NM	NS	NS	ZO
ZO	ZO	NS	NS	NS	NS	NS	ZO
PS	ZO	ZO	ZO	ZO	ZO	ZO	ZO
PM	PB	NS	PS	PS	PS	PS	PB
PB	PB	PM	PM	PM	PS	PS	PB

SIMULATION ANALYSIS

The fuzzy PID control strategy is applied to hydraulic lifting system, and compared with the traditional PID control, the MATLAB simulation. In the process of simulation, work pressure by two motor control parameters, selection of variable displacement pump of 135 ml/r, engine speed of 1000 r/min, weighs 5000 kg, the simulation results are shown in figure 3~4.

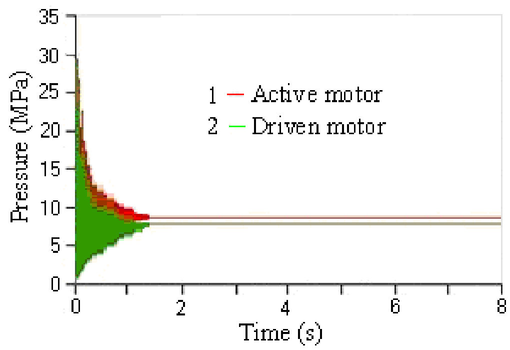

Fig.3 The simulation curve of traditional PID control

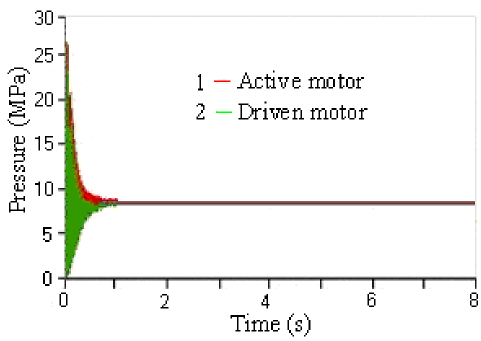

Fig.4 The simulation curve of fuzzy PID control

Can be seen from the simulation results, in the process of control, two control methods are to take a good control effect, compared with the traditional

PID control strategy, fuzzy PID control strategy is faster response, higher control precision.

EXPERIMENT

In order to verify the validity and usefulness of simulation control method, using the same parameters and simulation experiment, the results shown in Figure 5~6.

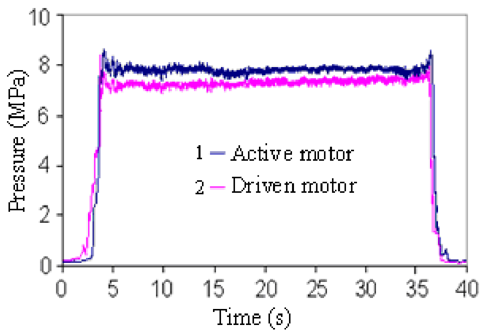

Fig.5 The simulation curve of traditional PID control

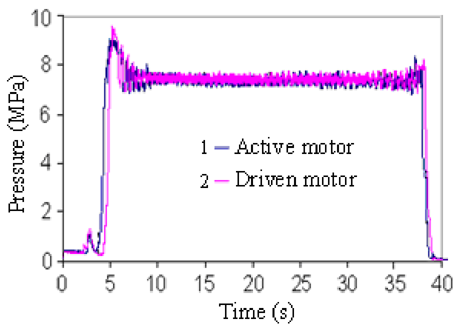

Fig.6 The simulation curve of fuzzy PID control

CONCLUSION

In this paper, the dual motor dynamic characteristics of hydraulic lifting system are analyzed, and find out the relationship between the system parameters, provide the basis for the selection of control variable; The combination of fuzzy control and traditional PID, fuzzy PID control strategy is put forward, which overcome the traditional PID control strategy can't online always setting faults. Simulation and experimental results show that the method has good dynamic response, high control precision and strong robustness.

REFERENCES

[1] Li Jun-wei, Zhao Ke-ding, Wu Sheng-lin. Re- search on Dual Electro hydraulic Motors Synch- ronization via Fuzzy Control[J]. Machine Tool & Hydraulics，2003，25 (1):115~116.

[2] Zhang Guang-hong, Wu Ai-guo. Application of Fuzzy PID Control in 80MN Hydraulic Press Synchronization Control System[J]. Machine Tool & Hydraulics，2009, 37(10):175~180.

[3] Liu Xiao-feng，Liu Xin-hui，Wang Long-shan. Study on Speed Synchronization Control Large Crawler Crane Two-motor Based on Fuzzy PID[J]. Journal of Jilin University(Engineering and Technology Edition). 2011,41(5):659~664.

[4] D.A. Badley, D.W. Seward.The development control and operation of an autonomous robotic excavator [J]. Journal of Intelligent and Robotic Systems, 1998,21: 73～97.

[5] K.Hirasawa, S.Mabu, J.Hu. Propagation and control of stochastic signals through universal learning networks [J]. Neural Networks, 2006. 19(4): 487~499.

[6] S.Guo，L.Huang. Periodic oscillation for discrete-time Hopfield neural networks[J]. Physics Lettesr A, 2004. 329(3):199~206.

[7] Favennec G, Alirand M. Optimal response of pressure reducer and stability influence of the downstream line dynamics [J]. Modena, Italy, 2002(7):1~10.

[8] Cao Longbin, Dai Ruwei, 2008, "Fundamentals, Concepts, Analysis, Design and implementation", Beijing: Post &Telecom Press, China.

[9] Chella, A., Massimo Cossentino, Salvatore Gaglio, 2010, "Agent-oriented software patterns for rapid and affordable robot programming", Journal of systems and software, vol.83, No.4, pp 557-573.

[10] Muciente. M., Alcala F.J., Alcala R. Casillas J., 2010, A case study for learning behavior sin mobile robotics by evolutionary fuzzy systems, Expert System with Applications, vol.37, pp 1471-149.

[11] Xie Wei, Ma Jiachen, Yang Mingli, 2010, Agent-oriented architecture for Intelligent service robot, Proceedings of the 8th world congress on intelligent control and automation, pp 5964-5967.

[12] Xie Wei, Ma Jiachen, Yang Mingli, 2010, Design of hybrid architecture for intelligent service mobile robot, Proceeding of international cocnference on electrical and control engineering, pp 740-743.